

Venus Exploration



Analysis Group

VEXAG Update PSS

March 31, 2015

Lori S. Glaze, NASA GSFC - VEXAG Chair

Pat Beauchamp – Deputy VEXAG Chair

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What's on peoples' minds?



Discovery: NOW is the time for NASA to return to Venus

- No new Venus missions anywhere in the international community:
 - Venus Express has completed its mission
 - Akatsuki will attempt to achieve orbit in November, but orbit will not allow the primary core science that was originally planned
 - ESA's M4 has elected not to consider ANY planetary missions
 - ISRO interest in Venus; concept study expected (outcome to be reported Feb 2016)
- Venus is a key example needed for comparative planetology studies of formation and evolution of atmospheres, climates, surfaces, and interiors
- Mars 2020 is under way in earnest
- Outer planets have a flagship (Europa) and New Horizons arrives at Pluto this summer,
- DAWN and OSIRIS-REx are providing/will provide new data for small bodies
- LRO still going strong at the moon
- MESSENGER completes mission this spring, Bepicolombo to launch in 2017



R&A

- Mary Voytek (SSW caucus lead) spoke to the Venus community at the LPSC Venus Town Hall
 - 19% selection rate for Venus-related proposals is “on par” with overall SSW selection rate
 - Includes comparative studies
- Concern expressed about the low number of non-atmosphere Venus proposals submitted/selected
- Concern about programmatic balance – just because most of the submitted proposals cover a particular topic doesn’t mean that is all that should be selected
- Concern about lack of geology/geophysics in SSW?
 - Is this real or just a perception?
 - Communication could alleviate some concerns
- Some science questions will eventually require long-term (> a few hours) surface survival (e.g., geophysical networks); investments in power/thermal technology are needed, but opportunities for this type of development are lacking



Extreme Environments Centennial Challenge (EECC)

- Focus on long-term surface survival:
 - First targeting high temperature electronics
- Challenge is intended to trigger interest in helping solve technical challenges which would have applicability for long-lived Venus landers
- Discussion and ideas were solicited from prospective communities including via a technical interchange meeting in Oct., 2104
- Request For Information (RFI) was developed to gauge community interest. Currently going through approval process at NASA HQ
- If EECC RFI response level is sufficient, then rules and competition parameters will be developed
- POC: Tibor Kremic, Glenn Research Center



Venus Gravity Assist Science Opportunity (VeGASO) Panel

- Top-level advisory group for the assessment of possible science collaborations with NASA's Solar Probe Plus (SPP), ESA's Solar Orbiter (SO) and Bepi-Colombo missions during these mission fly-bys of Venus.
- The primary role of the VeGASO Panel is to:
 - identify/assess “unique” synergistic Venus science observations that could be performed using the many gravity assist opportunities of SPP, SO, and Bepi-Colombo,
 - Document findings and priorities for these possible collaborative science opportunities which map to the Venus Exploration Analysis Group (VEXAG) goals and objectives.

Schedule

- October 2014 - March 2015 - Bi Weekly Telecons
- November 18-19, 2014 – Strategic Coordinating Co-chairs Meeting
- Late January 2015 - Draft Report
- March 2015 - Final Report
- April 2015 – Report presentation to NASA HQ



- VEXAG Events/Activities:

- Venus Exploration Targets Workshop, May 19-21, 2014 (Houston, TX) – report coming soon!
- Venus Express: Successful aerobraking campaign summer of 2014; fuel depleted (Nov 2014); end of mission in January 2015 after almost 9 years
- Discovery missions proposals were submitted to PSD on February 16. As best we know:
 - ~ 28 proposals submitted
 - 4 Venus proposals
- LPSC: Venus Town Hall & Early Career Mixer
- Glenn Extreme Environments Chamber (GEER) will be “operational” on March 30; can simulate full Venus atmosphere chemistry at near surface T/P; large enough to test full scale instruments and hardware; propose through ROSES
- Akatsuki planning orbit insertion in November 2015; NASA has selected 2 Scientists in Residence and 4 Participating Scientists (6 total)
- Venus III Book in preparation (chapter drafts due 4/2)



- New Community Documents Finalized September 2014:
 - Goals, Objectives, and Investigations for Venus Exploration: 2014
 - Roadmap for Venus Exploration: 2014
 - Venus Technology Plan: 2014
- All available
 - VEXAG website (<http://www.lpi.usra.edu/vexag/>)



- Upcoming Meetings and Workshops:
 - Venus Science Priorities Workshop for Laboratory Measurements and Instrument Definition, April 7-8, 2015 (Hampton, VA)
 - 12th VEXAG meeting April 9
 - Comparative Tectonics and Geodynamics of Venus, Earth, and Exoplanets Conference, May 4-6, 2015 (Pasadena, CA)
 - Comparative Climatology of Terrestrial Planets II: Understanding How Climate Systems Work, September 8-11, 2015 (Moffet Field, CA)
 - 13th VEXAG meeting late fall 2015 (Washington, DC)

Venus Exploration

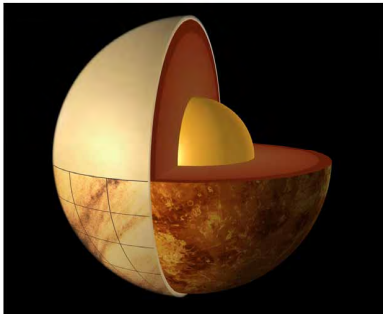
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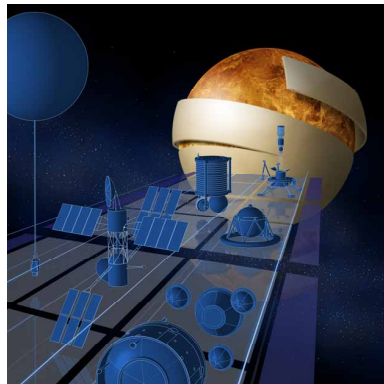
Goals, Objectives, and Investigations for Venus Exploration

May 2014



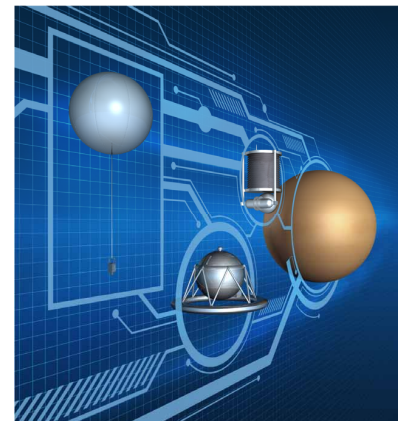
Roadmap for Venus Exploration

May 2014



Venus Technology Plan

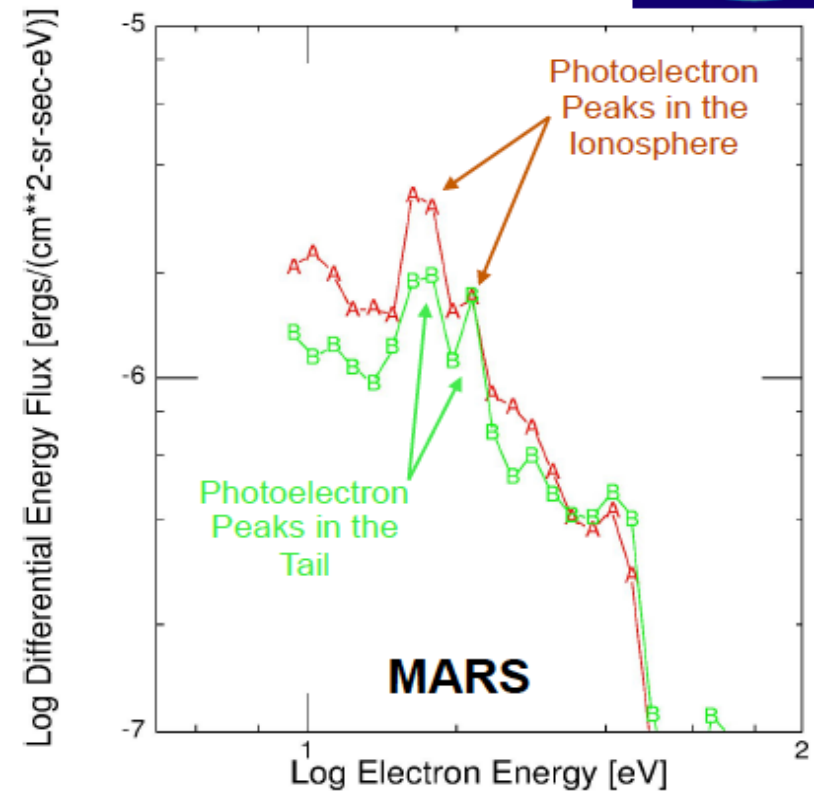
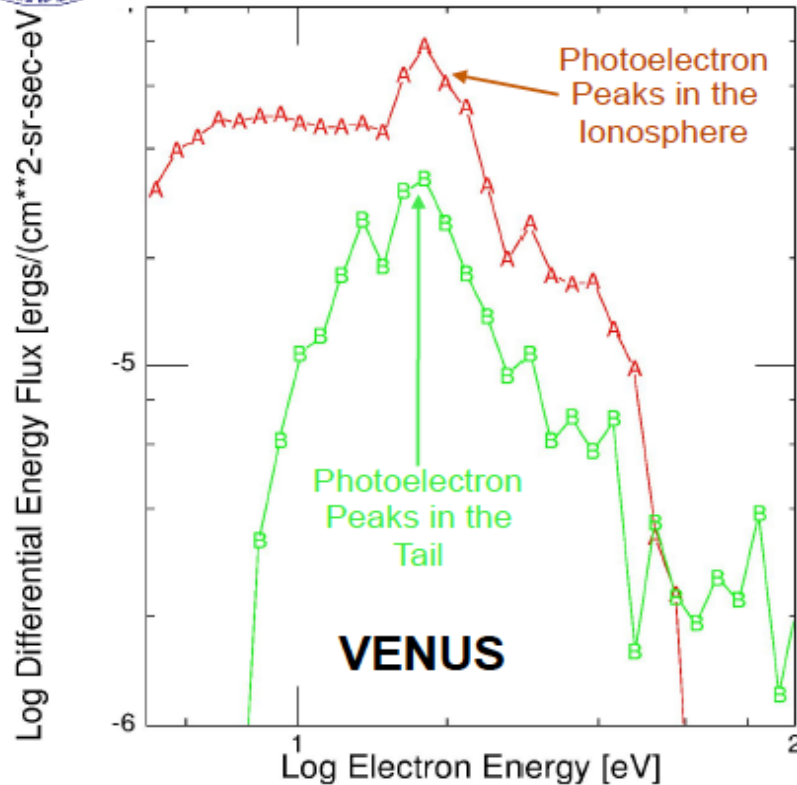
May 2014



SCIENCE NUGGETS



Similar Ionization Processes on Venus and Mars



Peaks in the electron spectrum are caused by solar HEII 30.4 nm ultraviolet light ionizing carbon dioxide and atomic oxygen in the atmosphere. The emitted electrons are observed in the dayside ionosphere near the ionization source; however, they are also observed deep in the planet's tail traveling away from the Sun. **This proves that the atmospheres of both Mars and Venus are being stripped away in an ionization process caused by the Sun.**

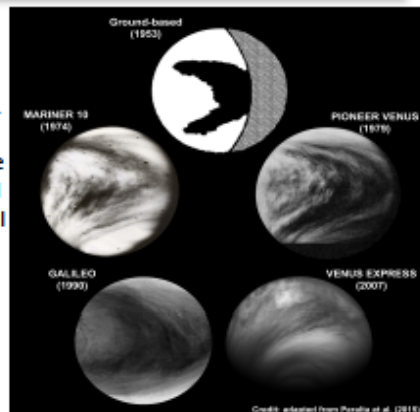
Tsang, S. M. E., A.J. Coates, G. H. Jones, R. A. Frahm, J. D. Winningham, S. Barabash, R. Lundin, and A. Fedorov, "Ionospheric Photoelectrons at Venus: Case Studies and First Observation in the Tail", *Planetary and Space Science*, in press, 2015

Venus's Y feature as a wind distorted wave

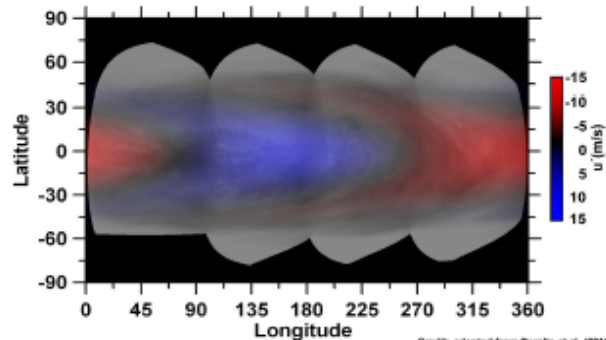
What is the Venus "Y" feature??

In the 1960s, a huge dark cloud structure was first observed on Venus through ultraviolet images.

This feature with the shape of a "Y" has been observed for many decades of spatial missions, and it has been interpreted to be a WAVE.



The "Y" propagates to the west and circles the planet about every 4 days. It has been recently discovered that where the "Y" is dark this wave "pushes" Venus winds to the west (red color), and where the cloud is bright the wave pushes the wind in the opposite sense (blue).

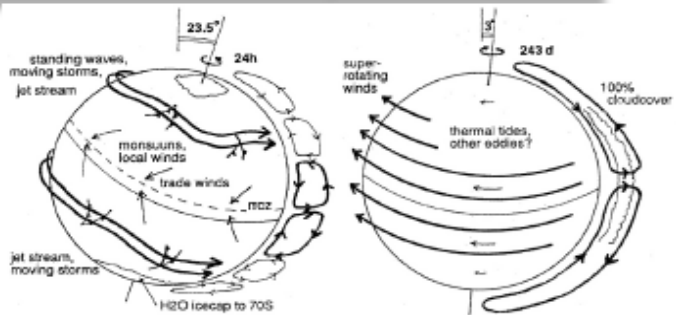


BUT, STILL WE WONDER... Why has the wave a "Y" shape? Why is it dark? Which is the reason for its life cycles?

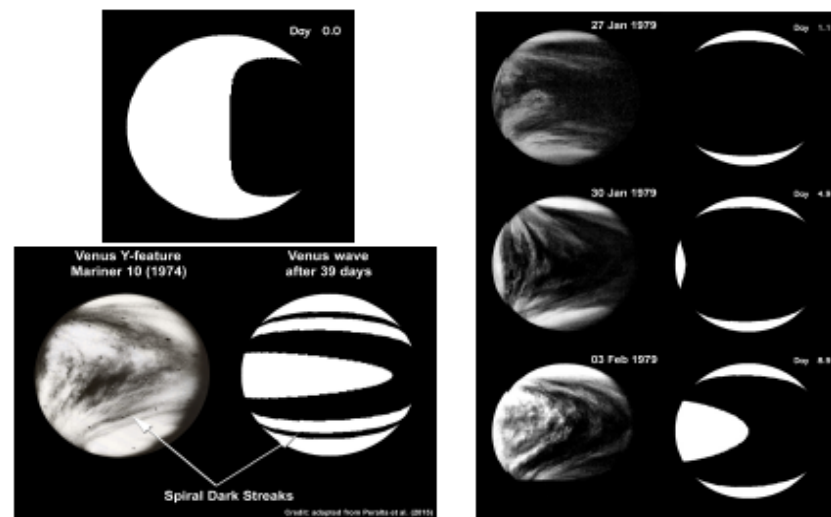
A new type of wave distorted by Venus winds

For the Earth it takes 24 hours to complete a rotation, while Venus is much slower. As a result, the atmospheric circulation in both planets is so different.

We have deduced a **new type of equatorial wave** that only appears in planets of slow rotation like Venus.



- This wave brings up an ultraviolet absorber commonly thought to exist below, and concentrates it at the cloud tops. This is why we see dark regions in UV images of the "Y".
- After being created, the wave becomes gradually distorted by the winds and adopts the "Y" shape until it is finally dissipated, matching the images from NASA's Pioneer Venus mission.



Maps of the Dynamic Venus Sub-Cloud Atmosphere

Simultaneous CO and OCS maps show a strong anticorrelation



CO



OCS

These maps reveal dynamical processes and chemical conversion of CO to OCS in the lower atmosphere.

Water vapor displays surprising variability and banding patterns



The banding patterns change on daily timescales and may be due to rainout events into the sub-cloud atmosphere

Qualitative color key (applies to all maps)

Less

Average

More

The first ground-based maps of Venus' sub-cloud atmosphere measured simultaneously over 1-2.5 μm reveal the interrelationship of multiple chemical species – and a lower atmosphere as dynamic as that above the clouds

- Strong banding patterns in water vapor are seen near the bottom of the cloud deck (~45 km) that may be indicative of cloud rainout
- Inexplicably, CO, OCS, H₂O, H₂SO₄, and SO₂ are more abundant in one hemisphere than the other, and some of these dichotomies shift hemispheres over a year
- Many species display correlation or anticorrelation with each other indicative of linked chemical and physical processes: e.g. CO and OCS, and H₂O, H₂SO₄, and cloud opacity
- Venus is a likely end state for terrestrial planet evolution, and hazy exo-Venuses may be common. **Understanding our sister planet can help us understand similar planets elsewhere.**

Arney et al. (2014) J. Geophys. Res. Planets, 119